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CHANGES IN A MANGROVE/SAMPHIRE COMMUNITY, NORTH ARM CREEK, SOUTH AUSTRALIA

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Summary

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Use of a computer GIS package to study aerial photographs of North Arm Creek (1979-1993) confirmed previous studies suggesting a landward migration of the grey mangrove, *Avicennia marina*, but seaward progradation was also apparent. Samphire communities were reduced in area by nearly two-thirds, with the majority of the lost area overgrown by mangroves. At the same time samphires colonised unvegetated areas and some areas previously occupied by mangroves. From 1979-85 the area colonised by samphire was similar to the area lost, but was less from 1985-93. It is suggested that several factors are responsible for the changes in distribution.

KEY WORDS: *Avicennia marina*, *Halosarcia*, *Sarcocornia*, mangrove, samphire, saltmarsh, temporo-spatial change, progradation, colonisation.

Introduction

North Arm Creek drains from the Wingfield/Dry Creek area of Adelaide northwards into the mangrove zone of Barker Inlet (Fig.1). The zone comprises a seaward fringe of the grey mangrove *Avicennia marina* (Forst) Vierh. var *resinifera* (Forst) Bakh., backed by a salt marsh comprising mixed samphires of the genera *Halosarcia* P. G. Wilson and *Sarcocornia* A. J. Scott. The mangroves and samphires form bands of variable width on both banks of the creek.

The creek has been used for the reception of stormwaters, sewage effluent and trade wastes. The wet coastal ecosystem edging the creek has been considerably modified since European settlement. In the late 1800s seawall embankments were built along the mangrove/samphire interface, and the samphire zone was used as pasturage. Salt production on the eastern side of the creek began in 1934 and progressively much of the low lying area inland of the seawall embankment has been ponded. On the western side of the creek the low lying land behind the seawall became a municipal refuse tip. In the 1970s a series of groynes supporting power pylons was built through the mangrove/samphire zone abutting the creek.

The more recent changes have resulted in changes to the water flows and tidal dynamics in the area. In 1986 Bradley[1] recorded large scale dieback of both mangroves and samphires in the vicinity of the power pylon groynes and recent field inspections have revealed that the area is only slowly being recolonised.

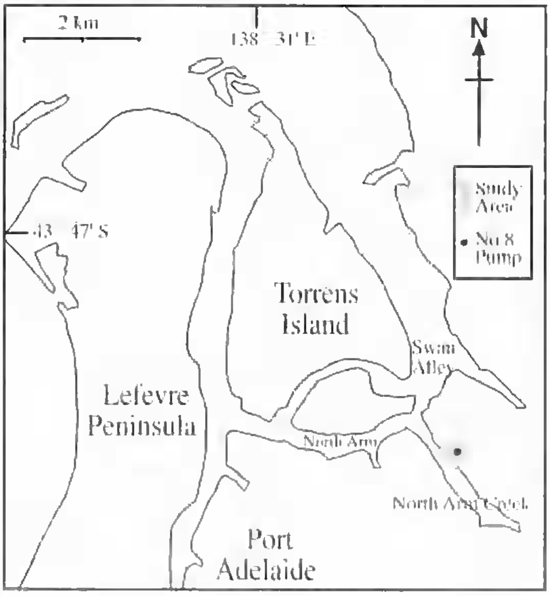

Fig. 1. Map of the region.

Aerial photographs of North Arm Creek, taken between 1949 and 1993, show changes in the mangrove and samphire communities. Some changes are marked, such as areas of dieback, or the inland advance of mangroves. The use of Geographic Information Systems (GIS) technology has allowed a closer look at the changes in one small region of the

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[1] BRADLEY, P. I. (1986) Baseline Study and Preliminary Evaluation of ICI Solar Evaporation Ponds' Bitterns Discharge on the Mangrove Community, with Supplement. Report provided to ICI Australia, Adelaide. (Unpubl.).

North Arm Creek coastal wetland, the drainage area of the Dry Creek Saltfields' No. 8 Pump.

The area is bounded on the east by a seawall and on the west by North Arm Creek. Running centrally across the area is a small creek that has been formed by the discharge of bitterns (brine that remains after salt crystallisation is complete) from the saltfields. The No. 8 Pump and its supply drains are clearly visible on aerial photographs.

Previous studies

Burton (1982) studied mangrove development north of Adelaide to the River Light using aerial photographs covering the period from 1935-1982. He noted that the mangrove stands showed different directions of growth at the two extremities of the study zone. Generally the northerly mangroves were prograding (extending seawards) while the southerly mangroves near Swan Alley were retreating inland across the samphire flats. Burton's paper discusses the possible causes of this difference, in particular discussing terrigenous supply and relative sea-level rise (eustatic rise and land subsidence).

During 1985-6 Bradley[1] examined the mangroves in the vicinity of the No. 8 Pump on North Arm Creek. He used visual comparisons of aerial photographs of the area taken in 1979 and 1985. He pegged two transect lines across the area and mapped the distribution, health and age of the vegetation along these. Plastic 30 cm rulers were attached to the transect pegs to determine possible sedimentation patterns. The alignment of the substrate on the rulers was recorded.

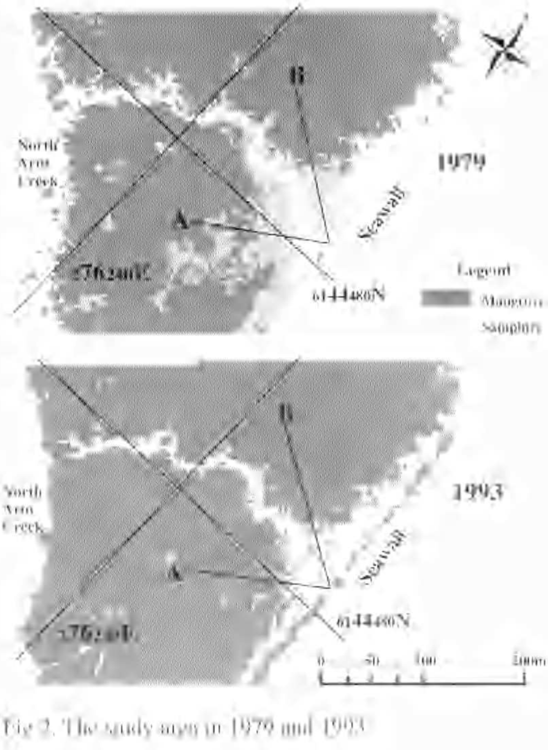


Fig 2. The study area in 1979 and 1993.

A further study of the North Arm Creek to Swan Alley area was undertaken by Blackburn[2] in 1994. He used GIS techniques to ascertain distribution changes within the mangrove and samphire communities. Blackburn[2] did not physically visit the North Arm Creek, but the photographs he examined indicated both landward and seaward progradation of mangroves.

The present study re-examines the area reported by Bradley[1] (Fig. 2). The review of the area combines a GIS analysis of aerial photographs (1949-1993) with a ground survey using Bradley's[1] existing transects. The study was constrained by growth of mangroves making access difficult, loss of some sediment rulers and loss of transect pegs nearer the seaward fringe.

Materials and Methods

Department of Environment and Natural Resources 1:1480 scale enlargements of four aerial survey photographs dated 10 January 1949, 19 March 1979, 18 February 1985 and 8 December 1993 were manually digitised into a form suitable for use in the GIS mapping package TNTmips Lite. The three more recent photographs, dating from 1979 to 1993, were georectified using man-made structures on the neighbouring saltfield as control points, along with isolated mangrove (*A. marina*) trees that were identifiable through the series of photographs. The 1949 photograph shows a landscape so different from the present that georectification could only be accomplished by matching the angles of narrow "borrow-pits" along the sea-wall, so data from it were only used in a general manner in the present study.

The principal components of the mapped area were defined as mangroves, samphires or neither (water or bare mud). An analysis of the limits of vegetation over each of two periods (1979-1985 and 1985-1993) was undertaken to try to determine what the dynamics of the vegetative change were.

Fieldwork in 1996 included finding the transect pegs placed by Bradley[1] in 1985. The vegetation along the two transects was recorded and its height measured in metres using a measuring tape. Readings were also recorded where sediment rulers were still in place.

[2] Blackburn, D. (1994) Mapping Mangrove and Saltmarsh Communities Near the Bitterns Discharge Area. Kinhill Engineers, Adelaide. Report to Penrice Soda Products. (Unpubl.)

TABLE 1. *General changes in the vegetation, 1979-1993.*

	Mar-'79	Feb-'85 *	Dec-'93	Change, '79-'93
Mangroves (m^2)	73902	78608	88459	+14557
Samphire (m^2)	14173	12769	5340	- 8833
Vegetative cover (m2)	88075	91377	93799	+5724

TABLE 2. *Change rates of the principal components of the vegetation.*

	Area of each change class of the vegetation (m^2)		Annual rate of change	
	1979-1985	1985-1993	1979-1985	1985-1993
Mangrove to mangrove (no change)	69175	76974	-	-
Samphire to mangrove	6202	6098	1034	762
Mangrove to samphire	2913	620	486	78
Neither* to mangrove	3520	3758	587	470
Mangrove to neither*	1240	588	207	74
Neither* to samphire	3876	1163	646	145
Samphire to neither*	1923	3988	321	499
Samphire to samphire (no change)	5993	2650	-	-
Vegetative loss	3163	4576	527	572
Vegetative increase	7396	4921	1233	615
Rate of change in total vegetative cover			706	43

* "neither" indicates areas of bare mud or water.

Because the *A. marina* trees had grown considerably during the 11 years since the transect pegs were placed, locating the pegs past the 80 m mark on Transect A and the 110 m mark on Transect B might possibly have resulted in damage to the mangal and so no data were collected beyond these points.

Results

Vegetation mapping

A comparison for the period 1979-1993 shows extension of the mangrove canopy, and a reduction in the area covered by samphires, with an overall increase in vegetated area (Table 1). As the study zone is delimited on the landward side by the seawall embankment, the gain must either be the overgrowing of previously bare mud patches, or some seaward accession.

The results of the analysis of the limits of vegetation from 1979-1985 and 1985-1993 are summarised in Table 2.

The largest change over the period was an increase of mangroves at the expense of the samphire community. However, the extension of both mangroves and samphires over bare mud and into water areas is also occurring, along with samphire colonisation of areas previously supporting mangroves. Erosion is occurring in some areas of samphire.

Samphire has given way to mangrove at their interface as the mangrove has extended inland. Almost the entire central samphire zone has been succeeded by mangroves and the trees have also occupied many of the creek lines as well as colonising the bare mud areas along the seawall embankment. Site visits in July and September 1996 revealed juvenile mangroves growing along the No. 8 Pump discharge channel and specimens more than 4 m high growing along the seawall within 40 m of the discharge point.

Some mangrove areas have been replaced by samphire or by bare mud. This has mainly occurred in the southern part of the study area but also along the bitterns discharge creek.

Along the seaward edge, progradation of mangroves is apparent along the entire length of the study zone. The extension is most marked in the southern areas, with a maximum advance of approximately 25-30 m in the 14 years from 1979-1993.

In the northern part of the study zone the seaward progression consisted mainly of infilling the many invaginations and embayments around isolated trees and the advance was between 10 and 15 m. The cause of the slower progradation of mangroves in the northern area is uncertain but the infilling of semi-enclosed areas suggests that low water flow rates in the sheltered areas were conducive to sediment accretion, whereas the actual seaward fringe may have been exposed to stronger wave action.

The samphire community has also been extending, and has become established on previously bare mud; there are now samphires along the seawall within 15 m

TABLE 3. *Sedimentation readings along the transects.*

Distance along transect	A Transect			B Transect		
	1985 initial reading	1986 reading (change)	1996 reading (change)	1985 initial reading	1986 reading (change)	1996 reading (change)
0 m	5.2	6.3 (-1.1 cm)	na	5.2	6.3 (-1.1 cm)	na
10 m	6.6	8 (-1.4 cm)	3 (+5.0 cm)	4.5	4.6 (-0.1 cm)	7 (-2.4 cm)
20 m	4.3	5.2 (-0.9 cm)	4 (+1.2 cm)	4	3.8 (+0.2 cm)	na
50 m	8	7.5 (+0.5 cm)	na	7	6.2 (+0.8 cm)	na
100 m	6.1	6.1 (no change)	na	6.3	6.3 (no change)	5.5 (+0.8 cm)

Note 1: 1985 & 1986 readings from Bradley (1986)[1].
Note 2: Readings are the alignment of the substrate against 30 cm plastic rulers attached to the transect pegs. Zero is to the top of the ruler.

of the discharge point. As the creeks are being infiltrated by mangroves, new areas for samphire colonisation have appeared. Much of the new growth is along the seawall and to the north of the study area, where the ETSA groyne has altered the tidal circulation.

The bitterns discharge does not appear to have affected growth of samphires negatively, possibly because the species are adapted to surviving in high salinity regimes, but samphire has been eroded away in some areas along the bitterns discharge creek.

Transects

Figure 3 presents the 1985 and 1996 heights of the vegetation along Bradley's[1] existing transects and shows the maturation of young stands of mangroves and the new colonisation (by mangroves and samphire) of areas closer to the discharge point. The 1996 data were collected along the transects in September. The forests are now so dense that accessing the pegs is difficult and so the transects do not continue to the original 150 m point.

Sedimentation

The bitterns discharge creek has formed since the 1949 aerial photograph was taken and Bradley's[1] report expressed some concern that erosion might be occurring in this creek near the discharge point. He examined sedimentation patterns away from the immediate discharge point by attaching plastic rulers to the transect pegs and recording the relative height of the substrate at each location.

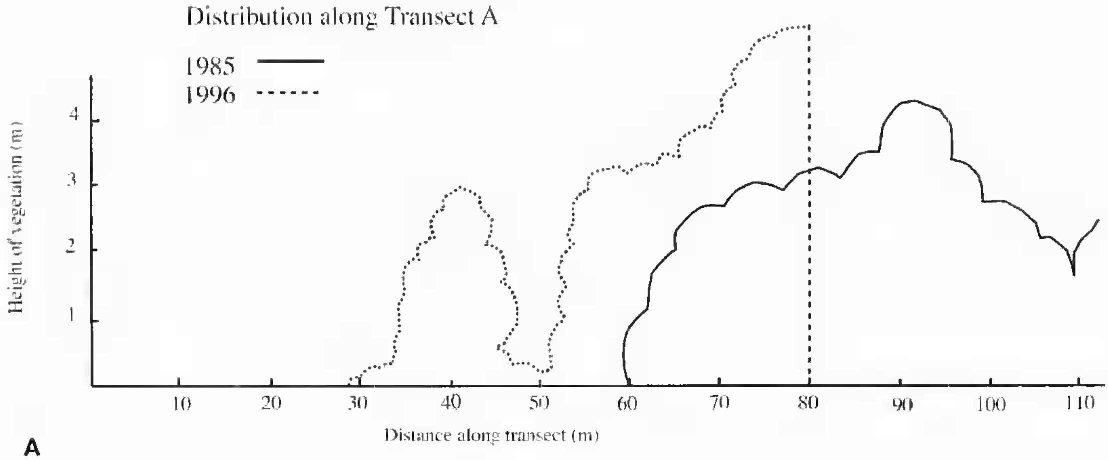
In response to Bradley's[1] finding during the initial observation period (1985-1986) that some erosion was occurring near the discharge point, saltfield personnel deposited concrete blocks in the drain to break up the flow. To determine the types of change that might have been occurring since 1985/86, the rulers were examined in September 1996 where they still existed. The few remaining sediment rulers indicated that the hydrology of the area may have changed. These 1996 readings are presented (Table 3) together with Bradley's[1] 1985 and 1986 readings.

The southern transect (Transect A) shows deposition to have occurred within 10 m of, and possibly closer to, the discharge point. The topography of the transect is smooth, with no creeks crossing it, so sedimentation may be relatively uniform across the area.

The northern transect has several small creeks crossing it, and the erosion/sedimentation pattern is more complex. The lack of rulers makes it difficult to interpret. However, the area closest to the discharge point has eroded somewhat over the last 10 years, forming a creek line. At low tide any discharge follows the existing creeks (slightly to the north before turning westerly), which have become more defined as mangroves have colonised the flats around them. The creek at 60 m is not recorded as having a sediment ruler on Bradley's[1] original sediment table, but a reading of the topographic plan of the transect done in 1985 shows the creek to be about 15 cm deep; the current reading is 14 cm. The ruler on the 100 m transect peg in the main forested area along the northern transect shows a small sediment gain.

Discussion

The detailed GIS study was possible because sufficient markers were visible in aerial photographs



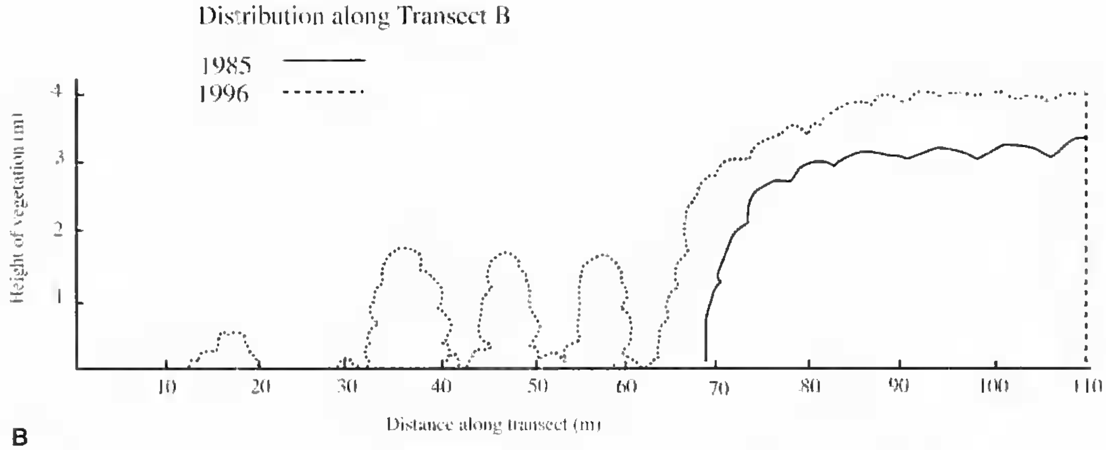


Fig. 3 A. Height distribution of vegetation along Transect A B. Height distribution of vegetation along Transect B.

to allow precise georectification. The 1949 photograph lacked some markers, reducing confidence in the precision of its georectification. However, this earlier photograph provides some insight into changes in vegetation patterns. The main differences include:

1. a larger area of vegetation in 1949 between the seawall and North Arm Creek; mangroves extended further out into the creek,
2. no creek in the location of the current bitterns discharge creek and the land inside the seawall was grazing land,
3. a wide expanse of samphires, with mangroves penetrating from North Arm Creek in towards the seawall along depressions, and
4. areas of mangrove dieback just behind the seaward fringe of mangroves.

The 1949 photograph showed that the mangroves in North Arm Creek were already retreating inland, so the seaward expansion visible in the post-1979 photographs must have started before 1979 but after 1949.

It is postulated that there has been an advance and regression of the mangroves with relatively small changes in water flow patterns. According to Hodgson *et al.* (1966)[3] North Arm Creek received the flow of effluent from the Islington Sewage Farm from 1881 through to the opening of the Bolivar Sewage Treatment Works in the 1960s.

During the operation of the sewage farm, nutrient rich water would have been released into North Arm Creek. The effluent may have supported algal blooms that could have caused the sporadic oxygen depletion in the waters of the creek recorded by Hodgson (1959)[4] . Induced anaerobic conditions are reported to cause the asphyxiation death of areas of mangroves (Diop *et al.* 1997) and this may explain the areas of dieback visible in the 1949 photograph.

The changes in the mangrove/samphire communities visible in the 1979-1993 photographs confirm previous studies that have suggested that a landward migration of *A. marina* is occurring in the southern reaches of Barker Inlet resulting in a reduction of the area of samphires. However mangroves are also prograding seawards and covering a larger area, suggesting that the growth and distribution pattern is not a response to a single factor.

While land subsidence/sea-level rise (Burton 1982) may be responsible for the landward progradation, it cannot account for simultaneous seaward progradation. Sedimentation readings from the transect rulers indicate that sediment is accumulating over much of the area and that any lowering of the land surface is likely to be a widespread landform settlement (PPK 1992[5]) of the sedimentary coastal deposits rather than a lack of sediment supply or erosion *per se*, except in specific areas such as creek lines and patches of mangrove dieback.

Samphire communities over the period 1979-1993 were reduced in area by nearly ²/₃ despite the overall gain in vegetated area. Most of the lost area was overgrown by mangroves. However, the direction of change was not entirely one way, as samphires colonised areas previously occupied by mangroves plus areas of mud/water. During the earlier period, between 1979 and 1985, the area of new samphire growth each year nearly matched the area lost, so that there was an apparent loss of only 200 m^2 of samphire annually. The later period (1985-1993) showed a slowing in newly colonised areas of samphire. Although the area overgrown by mangrove or eroded each year remained about the same as in the earlier period, the rate of loss appeared higher (1000 m^2 annually) because there was little colonisation of new areas by samphire

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